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STANDARDIZED CATCH RATES IN NUMBER OF FISH BY AGE FOR THE NORTH ATLANTIC SWORDFISH (*XIPHIAS GLADIUS*) OF THE SPANISH LONGLINE FLEET, FOR THE PERIOD 1983-2011

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SUMMARY

Standardized catch rates in number of fish by age were updated using log-normal General Linear Modeling (GLM) from trips carried out by the Spanish surface longline fleet fishing swordfish in the North Atlantic stock. Indices were developed for a 29 year period (1983-2011) for ages ranging from 1 to 5+, using a sex-combined growth model for ageing the size data per trip. The criteria used to define areas, time periods and models were similar to those used in previous papers. However, the models also take into consideration new information such as gear style and a target variable as the analyses by age carried out in the past hadn't taken into account these two important changes in the fishing strategy which have occurred in recent periods. The base case models explained between 42% and 45% of the CPUE variability. The age 1 standardized index suggests a more positive scenario of recruitment after 1996 with a mean overall level around double that of the previous and less favorable phase occurred up to that year.

RESUMÉ

Les taux de capture standardisés en nombre de poissons par âge ont été actualisés à l'aide de la modélisation linéaire généralisée log-normale (GLM) obtenus des sorties réalisées par la flottille palangrière de surface espagnole pêchant l'espadon de l'Atlantique Nord. Des indices ont été élaborés pour une période de 29 ans (1983-2011) pour des âges allant de 1 à 5+, à l'aide d'un modèle de croissance de sexe combiné pour déterminer l'âge d'après les données de taille par sortie. Les critères utilisés pour définir des zones, des périodes temporelles et des modèles étaient similaires à ceux utilisés dans des documents antérieurs. Toutefois, les modèles tiennent également compte des nouvelles informations, telles que le style de l'engin et une variable cible, étant donné que les analyses par âge réalisées par le passé n'avaient pas tenu compte de ces deux importants changements récemment survenus dans la stratégie de pêche. Les cas de base des modèles expliquaient entre 42% et 45% de la variabilité de la CPUE. L'indice standardisé d'âge 1 suggère un scénario de recrutement plus positif après 1996, avec un niveau global moyen environ le double par rapport à celui correspondant à une phase moins favorable survenue jusqu'à cette année.

RESUMEN

Se actualizaron las tasas de captura normalizadas en número de peces por edad mediante Modelos Lineales Generalizados (GLM) del tipo log-normal a partir de mareas individualizadas realizadas por la flota española de palangre de superficie de pez espada en el stock del Atlántico norte. Los índices fueron desarrollados para un periodo de 29 años (1983-201) para edades entre 1 y 5+ años usando un modelo de crecimiento tipo sexo-combinado para convertir los muestreos de talla por marea en captura por edad. El criterio usado para definir las áreas, periodos temporales y modelos fue similar al aplicado en documentos anteriores. Sin embargo, en este caso los modelos también tuvieron en cuenta nueva información, tal como estilo de arte de pesca y una variable de direccionamiento, ya que los análisis precedentes por edad no habían tenido en cuenta estos dos importantes sucesos ocurridos en periodos recientes. Los modelos base-case explicaron entre el 42% y 45% de la variabilidad de la CPUE. El índice de CPUE estandarizada de la edad 1 sugiere un escenario más positivo de reclutamientos a partir de 1996, con un valor medio global de aproximadamente el doble sobre el correspondiente a una fase menos favorable ocurrida hasta ese año

KEYWORDS

Swordfish, age specific CPUE, GLM, longline

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1. Introduction

The standardized catch rates of the Atlantic swordfish were obtained in the last decades by means of GLM procedures from commercial fleets some of which targeted this species while others did not (i.e. Hoey *et al.* 1989, 1993, Anon. 1989, 2010, Nakano 1993, Mejuto 1993, 1994, Scott *et al*. 1993, Mejuto and de la Serna 1995, 2000, Mejuto *et al.* 1999, Ortiz and Scott 2003). Data collected for scientific purposes from the commercial Spanish surface longline fishery targeting swordfish were used to develop GLM standardized catch per unit effort for the North Atlantic swordfish stock using methods recommended by several authors and the ICCAT working groups (i.e. Robson 1966, Gavaris 1980, Kimura 1981, Anon. 1989, 2010). These indicators have been used as inputs for the stock assessment of the North Atlantic swordfish stock. The consistency in the fishing patterns and gear configuration during decades facilitated the interpretation of these catch rates obtained as indices of relative abundance.

Important changes in the fishing strategy and gear "style" of the Spanish fleet have been introduced and described since the end of the last century. The impact of these changes on the nominal and standardized CPUE of the Spanish fleet have been described in previous papers and compared with results obtained using different approaches (i.e. Mejuto *et al.* 1998, 1999, 2001, 2002, Mejuto and De la Serna 1997, 2000). However these new events have not been taken into account so far in CPUE age specific analyses of this longline fleet. Additional information which was now available from the period 1986-2011, such as the type of bait used and of gear style, it has not been considered in previous age specific analyses.

As previously described, the surface longline gear of the Spanish fleet has remained relatively constant over decades in terms of structure and configuration (Rey *et al.* 1988, Hoey *et al.* 1988). Some technological improvements in the fishing gear were introduced and described during those historical periods in order to make it easier to carry out handling involving setting out and hauling back the fishing gear. These improvements tended to allow for a greater number of hooks per set which were considered as nominal effort in the CPUE calculations. However, the monofilament style (originally based on the "Florida style longline") so-called "American style" was broadly introduced in the Atlantic Spanish fleet at the end of the last century and most vessels have been fishing with this new monofilament style since then (Mejuto and De la Serna 2000, Mejuto *et al*. 2003). On the other hand, the targeting criteria of the Spanish longline fleet fishing on the North Atlantic stock was historically based on targeting swordfish. But this strategy has become more diffuse in recent periods, focusing on a combination of swordfish and blue shark as both main and valuable species as it was also observed and reported for these or other group of species in the case of several Atlantic surface longline fleets. The "target variable" accounts for trips where tunas and/or sharks were predominant in the catch or potentially also targeted for some fleets. These changes in the fishing strategy of several fleets of the Atlantic have had significant effects on the swordfish standardized CPUE obtained (i.e. Hazin *et al.* 2010, Mejuto and De la Serna 2000, Ortiz 2010, Ortiz and Scott 2003, Ortiz *et al.* 2010, Paul and Neilson 2010).

2. Material and methods

The trip data used were obtained over a period of 29 years (1983-2011) from the Spanish longline fleet fishing on the North Atlantic swordfish stock. Data voluntarily provided for scientific purposes were recorded. The methods and specifications used in this paper aimed to be consistent as far us possible with previous analyses in order to facilitate the comparison. However, two important events which have occurred since the last analyses by age were also taken into consideration: a) The introduction of a new monofilament gear style (American style) and b) the change of the targeting criteria of this fleet related to the previous decades reported.

The sex-combined Gompertz's type equation (Anon. 1989) was used to obtain number of fish by age (ages 1 to 5+) from catch at size data sampled per trip. The conversion from size into age was carried out using software applying the "slicing" technique (Restrepo *pers. comm*.) updated on visual basic. The analysis by age (number per thousand hooks) was developed using the methods traditionally applied in the ICCAT swordfish working groups and reported in previous papers (Mejuto 1993, Mejuto and De la Serna 1995, 1997, Mejuto *et al*. 1998, 1999, 2003). Trips with size-sampling coverage below 85% of their catch in number were omitted from the base case analysis as it was implemented in previous analyses. Changes in the fishing strategy from the target species (target variable) as well as the gear style and the bait used were also considered for modeling.
The target variable "ratio" was defined for each trip as the percentage in weight of swordfish landed in relation to the swordfish and blue shark landed. After analyzing the behavior of this fleet over time, it was considered that this variable might be a good indicator criterion of the skippers (target intensity) belonging to the North Atlantic Spanish fleet (Mejuto and De la Serna 2000, Ortiz *et al.* 2010). The "ratio" values were categorized into ten categories of 10% intervals. The temporal definition corresponding to "quarters" was as follows: Q1 =

January, February, March; Q2 = April, May, June; Q3 = July, August, September; Q4 = October, November and December. Three levels of gear styles were defined: 1= traditional multifilament mainline, 3= new monofilament and 9: unknown. Three levels of bait types were also considered: 1= mackerel, 6= squid and 9= other types or combinations (García-Cortés *et al.* in press). The hypothetical boundary line between North and South Atlantic stocks was kept at 5ºN latitude as assumed by the ICCAT. The spatial definition used for final runs considered 5 areas as used in previous analyses in number by age as well as in number and biomass age combined (García-Cortés *et al.* in press).

The base case standardized log-normal CPUE analyses were performed using GLM procedures (*SAS 9.2 ver.*). The models were defined as: LOG (CPUE) = u + Y + Q + A + R + G + B + A*Q + e. Where: u = overall mean, Y= effect year, Q= effect time (quarters), A= effect area, R= effect 'ratio', G= effect gear style, B= bait type, e= logarithm of the normally distributed error term. More details about the methods can be found in papers previously cited.

Old trip records from the period 1983-1985 lack some necessary information for the new modeling approach, as regards details such as gear style and bait type used, as well as the "ratio" information between both main prevalent species. In such cases, taking into consideration the history and knowledge of the fishery, the traditional gear style and mackerel as bait were assumed for all trips during that initial period. A ratio equal to the average observed for trips of 1986 was retrospectively applied to all trips of the period 1983-1985. A sensitivity analysis was also run excluding the period 1983-1985 in order to assess the impact of such assumptions on the standardized CPUE trends obtained. Other sensitivity analyses were also performed considering a lower and less demanding size sampling coverage of 50% for the selection of trip records used for the sensitivity GLM run.

3. Results and discussion

A total number of 10,079 trips were available from the whole period 1983-2011. **Table 1** is a summary of the ANOVA results for age specific analysis. The number of observations finally used, R-square, mean square error (root) and F-statistics for each age class are provided. The base case model by age explained between 42%-45% of the CPUE variability.

Table 2 show the estimated parameters obtained from the CPUE analysis in number of fish by age for the base case run. The year, quarter and area are the most important factors for explaining the variability of the age 1 CPUE. The variable year seems to be especially important for age 1 suggesting that the inter-annual variability plays an important role. The ratio and year variables are the most important factors for explaining the variability of the other ages considered. The type III SS suggest a different ranking of the other factors for the different ages as would be expected in a species segregated by size-ages and targeted by fleets with extensive fishing experience. The bait factor regularly explained a minor part of the CPUE variability or it was not significant in some cases.

Figures 1 and **2** represent the normal fit, the frequency distribution of the standardized residuals and the normal probability qq-plot diagnosis of the GLM base case run for standardized CPUE in number of swordfish by age. **Figure 3** presents the variability box-plot of the standardized residuals by year for each age.

Table 3 provides information on estimated parameters, their standard error, CVs%, standardized CPUE by age and upper and lower 95% confidence limits obtained for base case run. The mean standardized CPUE by age and their confidence intervals 95% are plotted (**Figure 4)**. The results of age 1 suggest that the mean abundance of this age during the whole period 1997-2011 was 1.9 times greater than the mean level predicted for the period 1983-1996. This event was probably helped by the change of phase and more favorable environmental conditions which have been occurring in the North Atlantic since 1996 (**Figure 5**) as previously postulated (Mejuto 2007, Neilson *et al.* 2013).

The sensitivity analysis excluding the period 1983-1985 suggests that the criteria assumed for the lack of some of the factors modeled and the criteria applied for the assumptions did not have any effect on the standardized CPUE trends obtained for the period 1986-2011. On the other hand, the sensibility analysis including trips with at least a 50%sampling coverage of the catch in number of fish did not produce significant effects on most CPUE trends over time for the whole period analyzed. A minor impact was observed on the absolute values obtained for age 1, probably due to the effect of the minimum size regulation or other bias on some trips with lower size sampling coverage. But the general trends obtained versus the base case run were very similar although with a slightly lower fit achieved for all ages. These results suggest that in the case of the size-age specific CPUE analysis the size-sampling criteria used in each fleet could be an important factor to be assessed and considered in order to assume such results as reliable indicators by age. In this sense, any substitution procedure of size information among trips was implemented in these analyses and a very demanding criterion of minimum sampling coverage per trip was considered for the base case runs. Additional information about the geographical coverage of this fishery can be found in García-Cortés *et al.* (in press).

The first ICCAT recommendation on minimum size has been formally in force in July 1991 and fully implemented in 1992. Since then these recommendations (with different updates and formulations such as REC-90-2 or REC 95-10) have been held by ICCAT with affects on the respective fleets depending on the option chosen for each CPC. In the case of the EU fleets, the type of REC-90-02 which allowed tolerance of up to 15% of the catch in number has been implemented. However, this tolerance was unilaterally canceled by the EU at a domestic level between June 2007 and January 2009 (National Authority pers. comm.). So, some impacts on the data of fish under 125 cm, especially in year 2008, could be expected because of the change of tolerance. However, this legislative confusion still remains among some of the boats probably causing pernicious effects of the age 1 CPUE underestimations since 2008.

The current management system implemented at a domestic level for swordfish is based on a complex and demanding regulatory network based, *inter alia*, on lists of authorized vessels, gear regulations, fishing plans per company-boat, assignment of strict annual quota per vessel, etc. The quota system per boat makes vessels extend their fishing activity in an economically sustainable way all year round, moderating in many cases their levels of swordfish catches/catch rates per trip. The effect of this self-controlled fishing strategy on the standardized CPUE indicators is not easily modeled, but is likely to be producing an underestimation in the abundance index in relation to the fishing strategy of previous historical periods in which global annual quotas and different control measures were implemented at a domestic level.

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Table 1. Summary of ANOVA base case analysis in number of fish by age: Number of observations, R- square, mean square error (root) and F-statistics for each age considered.

YEARS	AGE	#OBSERV	R-Square	RMSE	F-STAT
1983-2011	1	9129	0.416393	0.957622	107.83
1983-2011	2	9851	0.446515	0.711232	131.63
1983-2011	3	9851	0.436032	0.653712	126.15
1983-2011	4	9604	0.420962	0.667857	115.63
1983-2011	5+	9446	0.430252	0.711103	118.12

Table 2. Summary of ANOVA by factor for CPUE base case analysis, in number by age in the North Atlantic stock for the 1983-2011 period.

YEARS	AGE	FACTOR	DF	Type III SS	M-Square	F-Value	Pr > F
1983-2011	1	yr	28	1084.487507	38.731697	42.24	<.0001
1983-2011	1	qtr	3	855.166308	285.055436	310.84	<.0001
1983-2011	1	area	4	493.130087	123.282522	134.44	<.0001
1983-2011	1	gear	2	108.906155	54.453078	59.38	<.0001
1983-2011	1	bait	2	15.181493	7.5907470	8.28	0.0003
1983-2011	1	ratio	9	337.513961	37.501551	40.89	<.0001
1983-2011	1	qtr*area	12	192.857425	16.071452	17.53	<.0001
1983-2011	2	yr	28	538.9750065	19.2491074	38.05	<.0001
1983-2011	2	qtr	3	156.6625739	52.2208580	103.23	<.0001
1983-2011	2	area	4	470.6366484	117.6591621	232.60	<.0001
1983-2011	2	gear	2	221.0323631	110.5161816	218.48	<.0001
1983-2011	2	bait	2	0.3474911	0.1737455	0.34	0.7093
1983-2011	2	ratio	9	855.3079446	95.0342161	187.87	<.0001
1983-2011	2	qtr*area	12	154.2293833	12.8524486	25.41	<.0001
1983-2011	3	yr	28	326.3878198	11.6567078	27.28	<.0001
1983-2011	3	qtr	3	9.8827294	3.2942431	7.71	<.0001
1983-2011	3	area	4	210.4923413	52.6230853	123.14	<.0001
1983-2011	3	gear	2	265.4491411	132.7245706	310.58	<.0001
1983-2011	3	bait	2	12.3604243	6.1802122	14.46	<.0001
1983-2011	3	ratio	9	993.2697035	110.3633004	258.26	<.0001
1983-2011	3	qtr*area	12	78.1698096	6.5141508	15.24	<.0001
1983-2011	4	yr	28	378.239130	13.508540	30.29	<.0001
1983-2011	4	qtr	3	85.453099	28.484366	63.86	<.0001
1983-2011	4	area	4	76.688710	19.172178	42.98	<.0001
1983-2011	4	gear	2	253.968082	126.984041	284.70	<.0001
1983-2011	4	bait	2	28.300947	14.150474	31.73	<.0001
1983-2011	4	ratio	9	1046.342220	116.260247	260.65	<.0001
1983-2011	4	qtr*area	12	30.460501	2.538375	5.69	<.0001
1983-2011	5+	yr	28	495.9186090	17.7113789	35.03	<.0001
1983-2011	5+	qtr	3	251.8943128	83.9647709	166.05	<.0001
1983-2011	5+	area	4	257.7727050	64.4431762	127.44	<.0001
1983-2011	5+	gear	2	161.6344156	80.8172078	159.82	<.0001
1983-2011	5+	bait	2	36.6728598	18.3364299	36.26	<.0001
1983-2011	5+	ratio	9	863.5754041	95.9528227	189.75	<.0001
1983-2011	5+	qtr*area	12	79.5143709	6.6261976	13.10	<.0001

Table 3. Estimated parameters (LSMEAN), standard error (STDERR), Coefficient of variation (CV%), relative CPUE in number by age (CPUEn) and upper and lower 95% confidence limits (UCPUEn, LCPUEn) for the case base analysis of the North Atlantic for the years 1983-2011.

	YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
Age 1							
	1983	-1.1809	0.2479	20.9955	0.5147	0.3166	0.1947
	1984	-1.1834	0.2476	20.9199	0.5130	0.3158	0.1944
	1985	-1.2017	0.2414	20.0867	0.4968	0.3096	0.1929
	1986	-0.8284	0.2345	28.3074	0.7109	0.4489	0.2835
	1987	-0.3836	0.2397	62.4700	1.1217	0.7012	0.4384
	1988	-0.1845	0.2323	125.9420	1.3470	0.8543	0.5418
	1989	-0.3260	0.2330	71.4733	1.1710	0.7417	0.4697
	1990	-0.9479	0.2332	24.6018	0.6290	0.3982	0.2521
	1991	-1.0263	0.2325	22.6567	0.5807	0.3681	0.2334
	1992	-0.9370	0.2319	24.7433	0.6340	0.4025	0.2555
	1993	-0.7371	0.2319	31.4656	0.7744	0.4916	0.3120
	1994	-0.7433	0.2313	31.1156	0.7686	0.4885	0.3104
	1995	-0.6793	0.2300	33.8564	0.8170	0.5206	0.3317
	1996	-0.6859	0.2300	33.5384	0.8118	0.5172	0.3295
	1997	0.0540	0.2311	428.1163	1.7053	1.0840	0.6891
	1998	-0.0865	0.2311	267.2912	1.4817	0.9420	0.5989
	1999	0.0891	0.2332	261.9203	1.7743	1.1233	0.7111
	2000	0.0813	0.2347	288.6470	1.7661	1.1150	0.7039
	2001	0.1166	0.2338	200.4631	1.8259	1.1548	0.7304
	2002	-0.2029	0.2333	115.0005	1.3252	0.8389	0.5311
	2003	-0.2187	0.2357	107.7701	1.3113	0.8262	0.5206
	2004	-0.0748	0.2399	320.7192	1.5284	0.9550	0.5967
	2005	-0.0700	0.2451	349.9500	1.5532	0.9608	0.5943
	2006	0.1951	0.2505	128.3694	2.0493	1.2542	0.7676
	2007	0.4150	0.2659	64.0771	2.6420	1.5689	0.9316
	2008	0.2585	0.2617	101.2574	2.2383	1.3401	0.8023
	2009	-0.4828	0.2621	54.2926	1.0675	0.6386	0.3820
	2010	-0.5056	0.2516	49.7498	1.0192	0.6225	0.3802
	2011	-0.0700	0.2585	369.1945	1.6001	0.9641	0.5808

Age 2	**YR**	**LSMEAN**	**STDERR**	**CV%**	**UCPUEn**	**CPUEn**	**LCPUEn**
	1983	-0.2565	0.1811	70.5958	1.1216	0.7866	0.5516
	1984	-0.4562	0.1797	39.3955	0.9159	0.6440	0.4528
	1985	-0.1135	0.1772	156.0469	1.2833	0.9068	0.6408
	1986	0.0865	0.1733	200.2080	1.5545	1.1069	0.7882
	1987	0.5032	0.1774	35.2499	2.3786	1.6801	1.1868
	1988	0.3168	0.1723	54.4057	1.9530	1.3932	0.9939
	1989	0.4991	0.1727	34.5936	2.3454	1.6720	1.1920
	1990	0.5835	0.1726	29.5880	2.5517	1.8192	1.2969
	1991	0.3077	0.1723	55.9841	1.9352	1.3807	0.9850
	1992	0.2776	0.1719	61.8989	1.8761	1.3396	0.9566
	1993	0.2625	0.1719	65.4719	1.8482	1.3196	0.9422
	1994	0.3482	0.1714	49.2290	2.0116	1.4375	1.0273
	1995	0.5904	0.1705	28.8778	2.5575	1.8310	1.3109
	1996	0.1499	0.1706	113.7673	1.6467	1.1788	0.8438
	1997	0.3062	0.1714	55.9856	1.9286	1.3783	0.9850
	1998	0.6480	0.1713	26.4410	2.7141	1.9399	1.3866
	1999	0.8127	0.1728	21.2614	3.2103	2.2880	1.6306
	2000	0.9562	0.1734	18.1301	3.7100	2.6412	1.8803
	2001	0.8965	0.1731	19.3064	3.4928	2.4880	1.7722

	2002	0.6361	0.1728	27.1664	2.6904	1.9175	1.3666
	2003	0.7031	0.1747	24.8503	2.8887	2.0510	1.4563
	2004	0.4735	0.1769	37.3603	2.3067	1.6309	1.1531
	2005	0.7312	0.1802	24.6448	3.0060	2.1116	1.4832
	2006	0.6405	0.1855	28.9604	2.7765	1.9303	1.3420
	2007	0.8818	0.1967	22.3113	3.6208	2.4623	1.6745
	2008	1.1853	0.1921	16.2041	4.8560	3.3327	2.2872
	2009	0.9234	0.1927	20.8622	3.7419	2.5651	1.7584
	2010	0.8045	0.1850	22.9910	3.2678	2.2741	1.5826
	2011	0.4331	0.1885	43.5125	2.2712	1.5697	1.0849
Age 3	**YR**	**LSMEAN**	**STDERR**	**CV%**	**UCPUEn**	**CPUEn**	**LCPUEn**
	1983	-0.1139	0.1661	145.7953	1.2528	0.9047	0.6533
	1984	-0.1368	0.1646	120.2997	1.2205	0.8840	0.6403
	1985	-0.0524	0.1625	310.1336	1.3223	0.9616	0.6993
	1986	-0.0016	0.1592	9765.6442	1.3813	1.0111	0.7401
	1987	0.2632	0.1630	61.9268	1.8149	1.3185	0.9579
	1988	0.0835	0.1584	189.6193	1.5015	1.1008	0.8071
	1989	0.0166	0.1587	957.2376	1.4053	1.0296	0.7544
	1990	0.2862	0.1587	55.4309	1.8401	1.3483	0.9879
	1991	0.3628	0.1583	43.6249	1.9849	1.4555	1.0673
	1992	0.2605	0.1579	60.6296	1.7906	1.3139	0.9641
	1993	0.1036	0.1580	152.5879	1.5308	1.1231	0.8239
	1994	-0.0543	0.1575	290.2893	1.3059	0.9590	0.7042
	1995	0.2546	0.1567	61.5484	1.7753	1.3059	0.9606
	1996	-0.0366	0.1568	428.0721	1.3270	0.9760	0.7178
	1997	-0.2445	0.1576	64.4540	1.0798	0.7929	0.5822
	1998	-0.1983	0.1576	79.4503	1.1308	0.8304	0.6098
	1999	0.1608	0.1588	98.7625	1.6237	1.1894	0.8712
	2000	0.4042	0.1594	39.4236	2.0735	1.5172	1.1102
	2001	0.3198	0.1591	49.7576	1.9045	1.3943	1.0208
	2002	0.1894	0.1588	83.8366	1.6709	1.2239	0.8965
	2003	0.2982	0.1606	53.8601	1.8698	1.3649	0.9963
	2004	-0.0085	0.1627	1922.6950	1.3821	1.0048	0.7305
	2005	0.0388	0.1656	426.9142	1.4580	1.0539	0.7618
	2006	-0.1225	0.1706	139.2443	1.2541	0.8976	0.6425
	2007	0.0412	0.1808	438.8835	1.5098	1.0592	0.7432
	2008	0.2190	0.1769	80.7773	1.7883	1.2644	0.8940
	2009	0.3865	0.1774	45.8977	2.1168	1.4951	1.0560
	2010	0.1053	0.1701	161.5881	1.5733	1.1272	0.8076
	2011	-0.0999	0.1736	173.7790	1.2911	0.9187	0.6537
Age 4	**YR**	**LSMEAN**	**STDERR**	**CV%**	**UCPUEn**	**CPUEn**	**LCPUEn**
	1983	0.0413	0.1698	411.0412	1.4747	1.0573	0.7580
	1984	0.0570	0.1681	295.0851	1.4927	1.0737	0.7723
	1985	0.0764	0.1660	217.3168	1.5153	1.0944	0.7904
	1986	-0.0301	0.1626	540.8380	1.3524	0.9833	0.7149
	1987	0.1112	0.1666	149.7482	1.5707	1.1332	0.8176
	1988	-0.0876	0.1619	184.8367	1.2748	0.9282	0.6759
	1989	-0.1300	0.1622	124.8249	1.2228	0.8898	0.6474
	1990	-0.1101	0.1622	147.2399	1.2471	0.9076	0.6604
	1991	0.0706	0.1618	229.1035	1.4930	1.0873	0.7919
	1992	0.0967	0.1614	166.9080	1.5312	1.1160	0.8133
	1993	-0.1282	0.1615	126.0201	1.2232	0.8913	0.6494

1994	-0.2947	0.1610	54.6368	1.0345	0.7545	0.5503
1995	-0.1588	0.1602	100.8438	1.1828	0.8642	0.6314
1996	-0.3639	0.1603	44.0435	0.9638	0.7040	0.5142
1997	-0.5304	0.1612	30.3933	0.8176	0.5961	0.4346
1998	-0.6194	0.1612	26.0244	0.7479	0.5453	0.3976
1999	-0.4814	0.1625	33.7585	0.8610	0.6261	0.4553
2000	-0.1237	0.1629	131.6415	1.2322	0.8954	0.6507
2001	-0.3493	0.1628	46.6134	0.9832	0.7146	0.5193
2002	-0.3417	0.1625	47.5549	0.9900	0.7200	0.5236
2003	-0.1662	0.1642	98.7905	1.1842	0.8584	0.6222
2004	-0.3759	0.1663	44.2482	0.9646	0.6963	0.5026
2005	-0.6072	0.1697	27.9388	0.7708	0.5528	0.3964
2006	-0.6792	0.1747	25.7215	0.7251	0.5148	0.3656
2007	-0.7094	0.1848	26.0548	0.7189	0.5004	0.3484
2008	-0.5801	0.1821	31.3938	0.8134	0.5692	0.3984
2009	-0.3040	0.1816	59.7467	1.0709	0.7501	0.5255
2010	-0.7416	0.1742	23.4854	0.6804	0.4836	0.3438
2011	-0.5097	0.1778	34.8768	0.8646	0.6103	0.4307

Age 5+	YR	LSMEAN	STDERR	CV%	UCPUEn	CPUEn	LCPUEn
	1983	0.1942	0.1807	93.0525	1.7588	1.2343	0.8662
	1984	0.2596	0.1790	68.9474	1.8708	1.3173	0.9276
	1985	0.1788	0.1768	98.8980	1.7176	1.2146	0.8589
	1986	0.0300	0.1732	576.7821	1.4687	1.0460	0.7450
	1987	0.0855	0.1774	207.3541	1.5665	1.1066	0.7817
	1988	-0.0989	0.1724	174.3577	1.2890	0.9194	0.6558
	1989	-0.1417	0.1727	121.9187	1.2359	0.8810	0.6280
	1990	-0.1955	0.1727	88.3557	1.1711	0.8348	0.5951
	1991	-0.0642	0.1722	268.0884	1.3340	0.9518	0.6791
	1992	0.0595	0.1719	288.8571	1.5085	1.0771	0.7691
	1993	-0.1096	0.1720	156.8406	1.2741	0.9095	0.6493
	1994	-0.2984	0.1715	57.4526	1.0537	0.7530	0.5381
	1995	-0.2521	0.1706	67.6595	1.1016	0.7885	0.5644
	1996	-0.4595	0.1708	37.1629	0.8956	0.6409	0.4586
	1997	-0.6544	0.1718	26.2466	0.7386	0.5275	0.3767
	1998	-0.6454	0.1719	26.6281	0.7454	0.5323	0.3801
	1999	-0.8326	0.1733	20.8136	0.6201	0.4415	0.3144
	2000	-0.2738	0.1735	63.3876	1.0848	0.7721	0.5495
	2001	-0.5370	0.1735	32.3066	0.8337	0.5934	0.4223
	2002	-0.4584	0.1733	37.8038	0.9015	0.6419	0.4570
	2003	-0.3283	0.1751	53.3445	1.0307	0.7313	0.5188
	2004	-0.4989	0.1773	35.5280	0.8730	0.6168	0.4358
	2005	-0.5761	0.1806	31.3413	0.8139	0.5713	0.4010
	2006	-0.6145	0.1864	30.3326	0.7931	0.5504	0.3819
	2007	-0.2322	0.1983	85.3938	1.1926	0.8085	0.5481
	2008	-0.3251	0.1933	59.4451	1.0750	0.7361	0.5040
	2009	-0.2402	0.1939	80.7137	1.1718	0.8014	0.5481
	2010	-0.6690	0.1861	27.8221	0.7506	0.5212	0.3619
	2011	-0.3861	0.1893	49.0429	1.0030	0.6920	0.4775

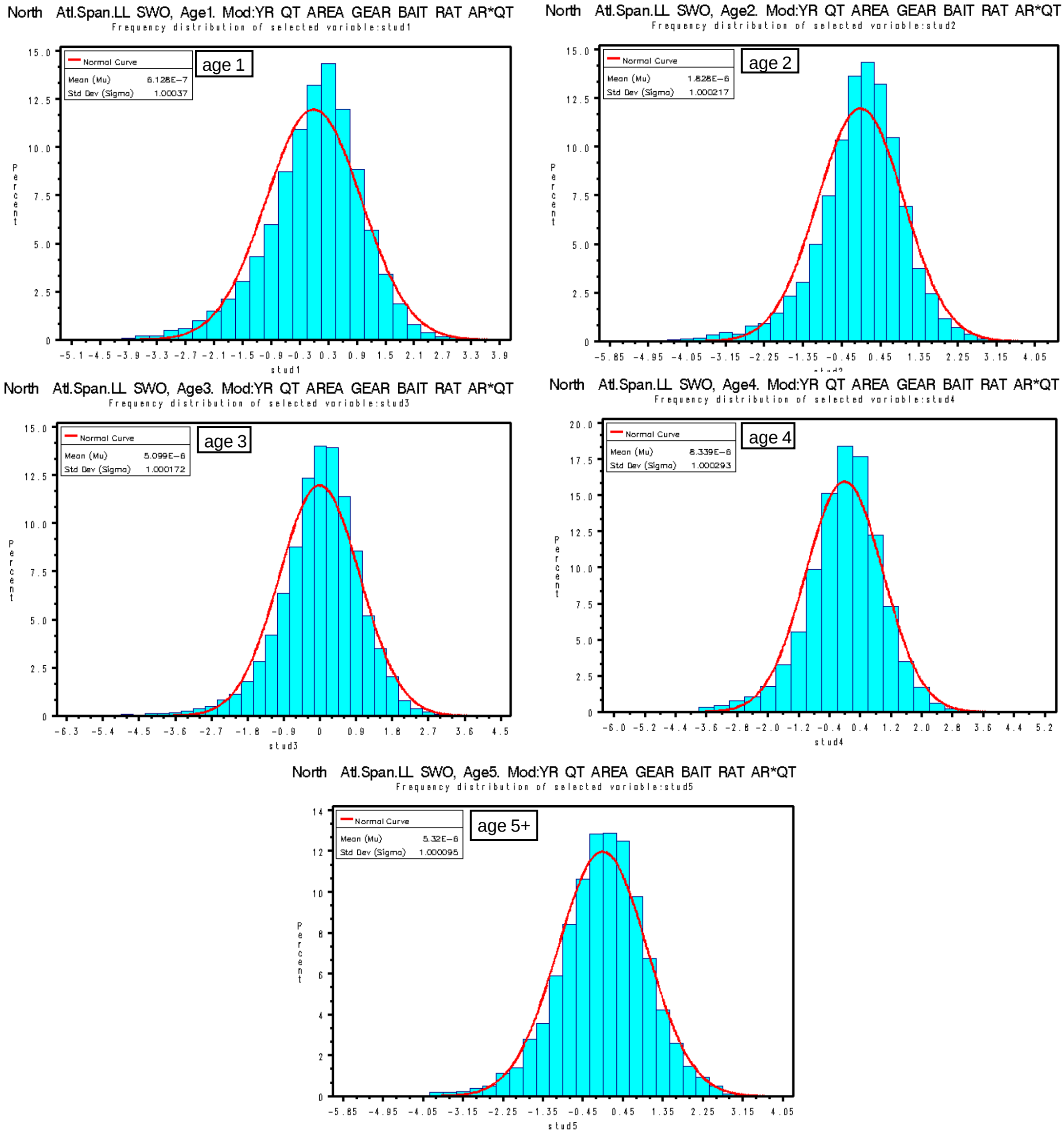

Figure 1. Normal fit and frequency distribution of the standardized residuals by age, years combined, obtained as diagnosis of the standardized CPUE in number of swordfish from the base case analysis of the North Atlantic stock for the period 1983-2011.

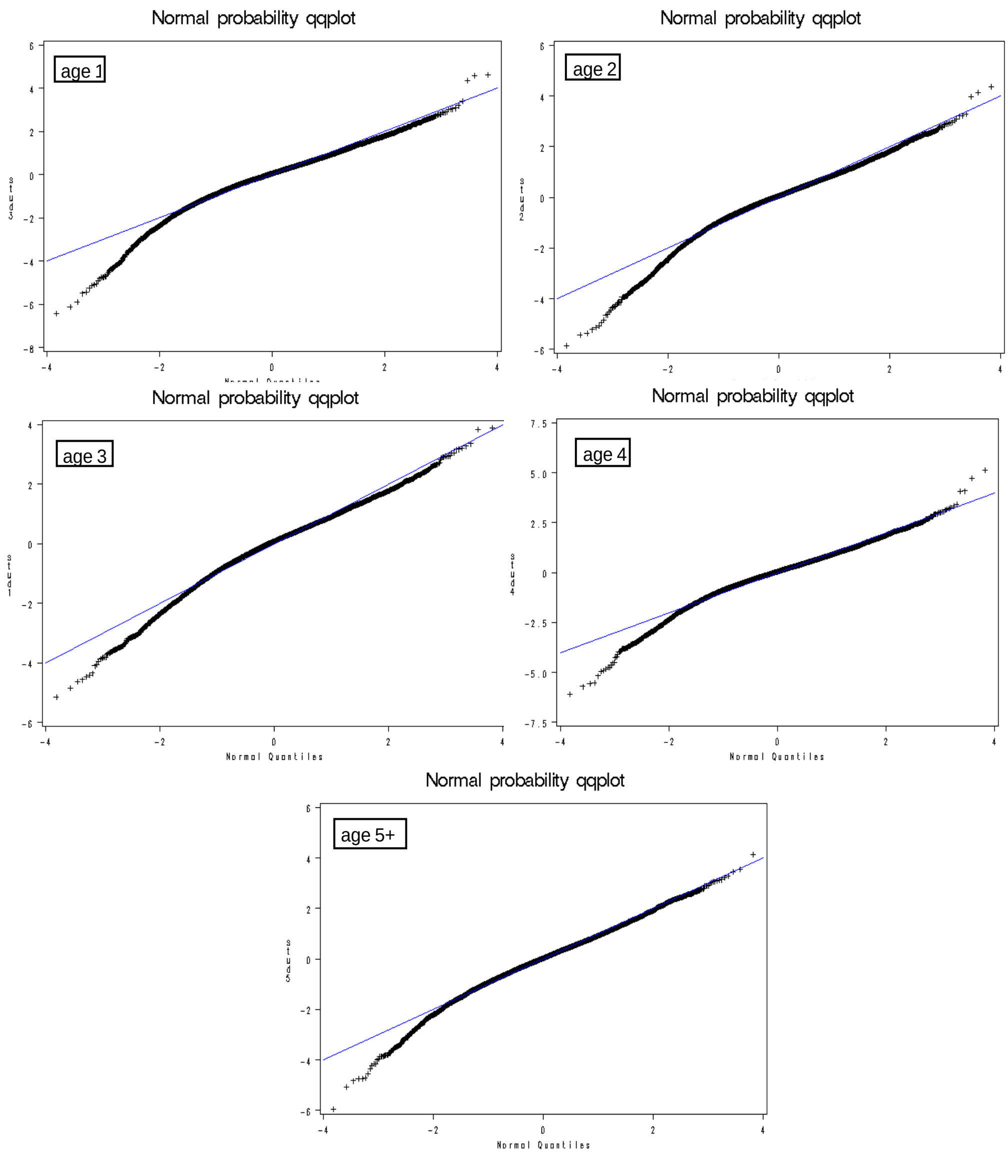

Figure 2. Normal probability qq-plot obtained by age of the GLM base case analysis for standardized CPUE in number of swordfish by age of the North Atlantic stock for the period 1983-2011.

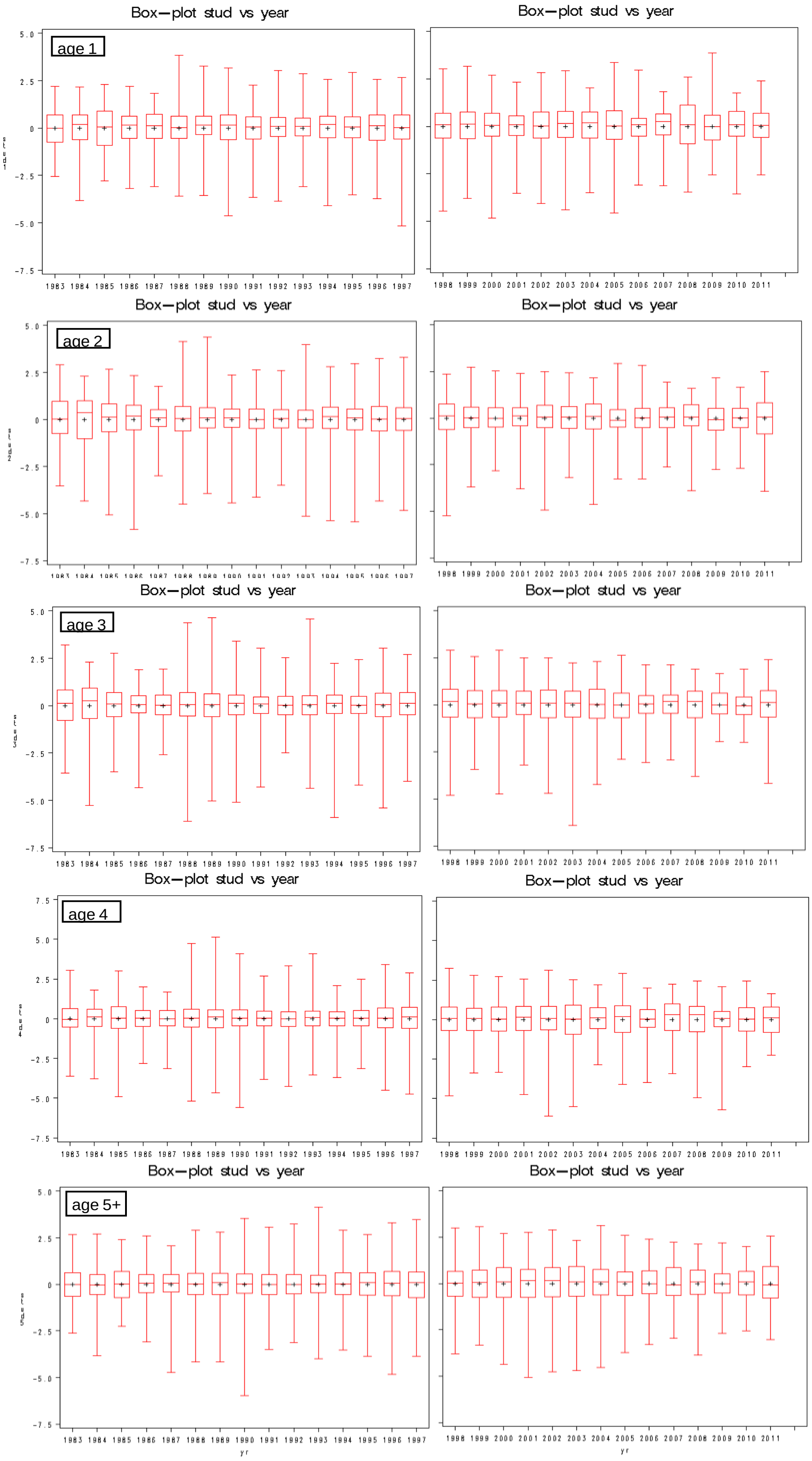

Figure 3. Variability box-plot of the standardized residuals by year obtained by age from the GLM base case analyses of the standardized CPUE in number of swordfish for North Atlantic stock during the period 1983-2011.

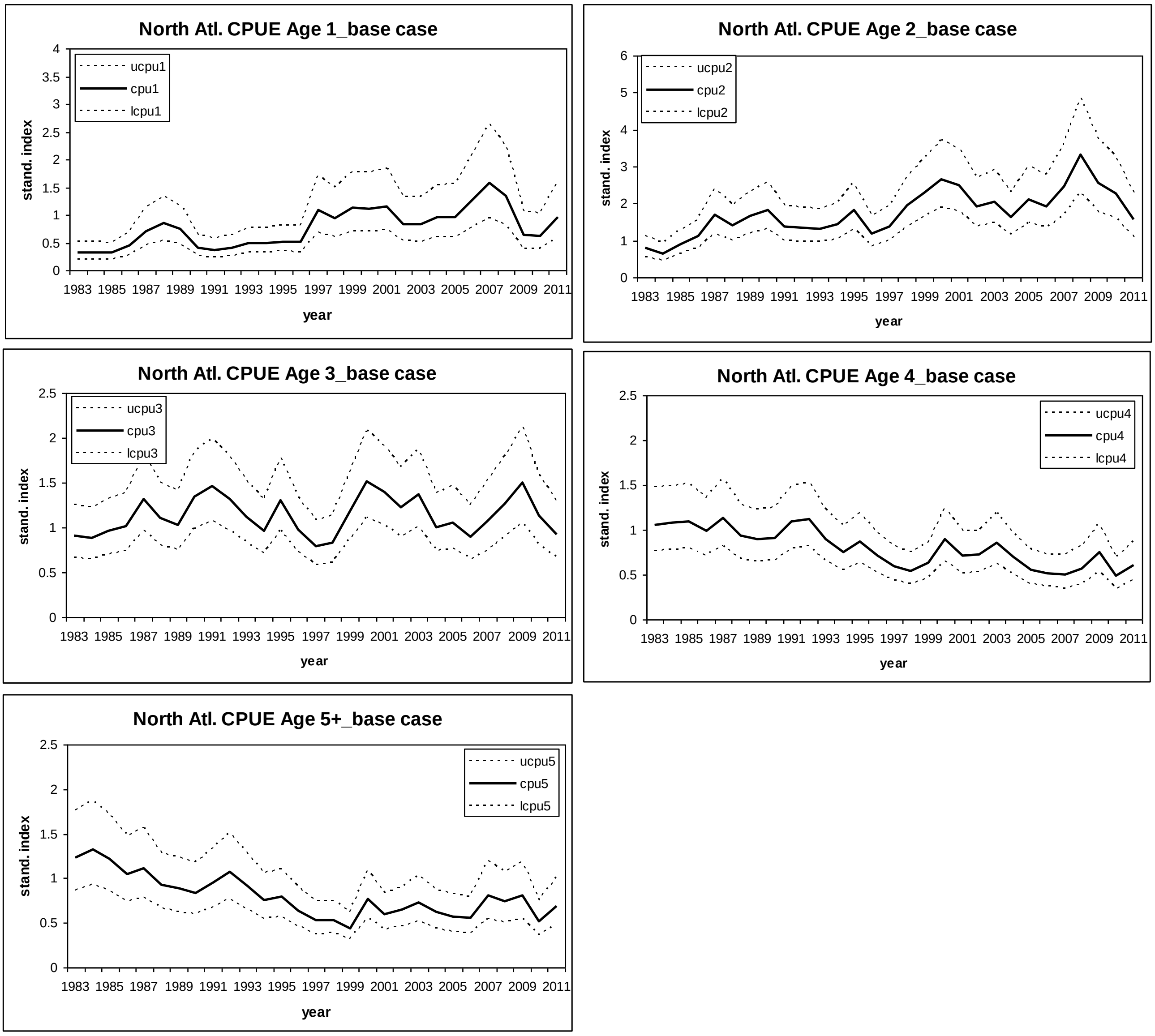

Figure 4. Annual change of the standardized catch rates in number of fish per thousand hooks for ages (1-5+) sex combined, and 95% confidence intervals obtained in the North Atlantic for the period 1983-2011.

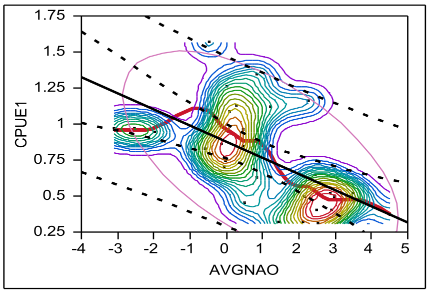

Figure 5. Bivariate fit of standardized CPUE age 1 (year *y*) vs. average of winter the NAO indices (years *y-1*and *y-2*), including linear and smoothing spline fits, normal ellipse and nonparametric bivariate density plot. Smoothing Spline R-squared fit (lambda=0.063096)= 0.463638. Linear R-squared fit= 0.3370 (F-Ratio=14.2346, Prob > F = 0.0008).